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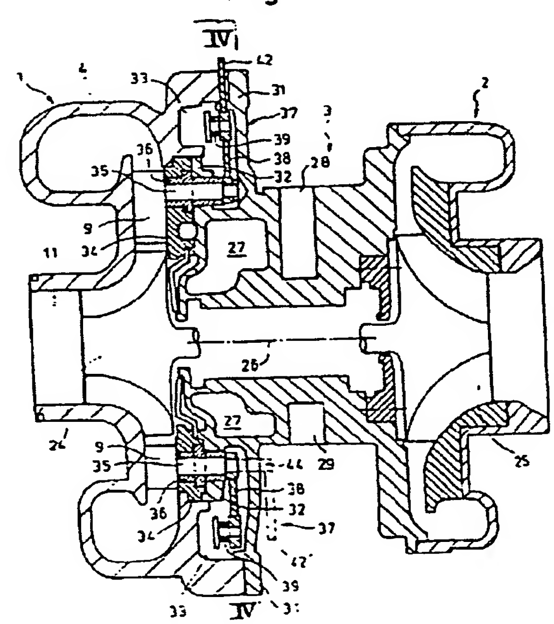
(54) **Variable geometry turbochargers.**

(57) A turbocharger includes a turbine (1) connected to a compressor (2) through a bearing casing (3) which defines an annular cooling passage (27). The turbine includes a housing (4) which defines a space accommodating a turbine wheel (24) and an inlet passage which communicates with the said space via an annular passage. A plurality of circumferentially spaced nozzle blades (9) are positioned in the said annular passage for guiding exhaust gases to the turbine wheel (24). The nozzle blades (9) are connected to one end of respective rotatable nozzle shafts (35) whose other end is connected to a common nozzle blade drive mechanism (37) which is operable to adjust the angle of all the nozzle blades (9) simultaneously. The nozzle shafts (35) are rotatably supported by the bearing casing (3) at positions adjacent the cooling fluid passage (27).

Fig. 3



VARIABLE GEOMETRY TURBOCHARGERS

The present invention relates to variable geometry turbochargers and is particularly concerned with nozzle blade angular adjustment devices for such turbochargers.

In order to improve the heat efficiency of various prime movers it is known to use a turbocharger which includes a turbine which is rotated by the exhaust gases from the prime mover and drives a compressor which in turn compresses and charges air into the prime mover.

In turbochargers of this type, the flow rate of the exhaust gases which constitute the power source varies with variations in the load on the prime mover. A variable geometry turbocharger has therefore been devised, as described in US-A-4741666, which includes a device for adjusting the angles of nozzle blades for guiding the exhaust gases to the turbine wheel in response to the load on the prime mover.

Such a nozzle blade angle adjustment device will be described below in more detail with reference to Figures 1 and 2 which are a diagrammatic longitudinal sectional view of the known turbocharger and a transverse sectional view on the line II-II in Figure 1, respectively.

The turbocharger comprises a turbine 1 and a compressor 2 connected to it via a bearing casing 3. The turbine 1 includes a casing 4 and a gas outlet cover 5 between which is clamped a shroud 6 which rotatably supports a plurality of nozzle shafts 7 by way of a bearing 8. Each shaft 7 has a nozzle blade 9 at one end adjacent to the casing 4 and a nozzle link 10 at its other end adjacent to the cover 5. The nozzle blades are positioned, circumferentially spaced, in the passage or gap between a volute passage defined by the casing 4 and the cylindrical space accommodating the turbine wheel 24.

The cover 5 and shroud 6 together define a space 12 of toroidal shape which surrounds a gas outlet 11 and which accommodates a rotatable nozzle drive ring 13 and the nozzle links 10 to which it is connected. The ring 13 has pins 14 and slide joints 15 projecting from it. The joints 15 are radially slidably fitted into a slide groove 16 defined at one end of the respective link 10. The ring 13 has also a pin 17 and a slide joint 18 projecting from it. The joint 18 is radially slidably fitted into the guide groove 20 at one end of a drive link 19. The drive link 19 is securely attached at its rear end to one end of a drive shaft 22 which passes through the cover 5 through a bearing 21. The other end of the shaft 22 is connected to a drive lever 23. Reference numeral 25 indicates a compressor wheel; 26, the turbine shaft; 27, a cooling water passage; 28, an oil supply opening; 29, an oil discharge opening; and 30, guides for guiding the rotating ring 13.

When the drive lever 23 is driven by an external power source, the nozzle ring 13 is caused to rotate through the shaft 22 and the link 19. In response to such rotation of the ring 13, the angles of all of the nozzle blades 9 are simultaneously varied through the nozzle links 10.

The known nozzle blade adjustment device described above, rises to a temperature in excess of 450° C up to about 500° C during operation and is thus too hot to lubricate (since any lubricating oil supplied would be carbonised due to the high temperature). As a result, the following problems arise:

Slide elements which slide or permit sliding in the radial direction of the ring 13 and thus of the turbine wheel 24, such as the slide joints 15 and 18 and the slide grooves 16 and 20, are adversely affected by oxidation at high temperatures and by wear caused by the slide motion. As a result, the surface of the slide elements is covered with a fragile, oxidised layer due to oxidisation at high temperatures and this oxidised layer is readily worn due to the sliding contact. This is repeated many times, resulting in breakdown of the slide elements. Consequently the reliability of the device is not satisfactory because of its low durability.

It is thus an object of the present invention to provide a variable geometry turbocharger with a nozzle blade angular adjustment device which can be maintained at a relatively low temperature to reduce the adverse effects caused by oxidisation at high temperatures and which has no slide elements slidable in the radial direction of the turbine wheel and subject to sliding wear, thereby improving the service life and reliability of the device.

According to the present invention a turbocharger of the type including a turbine connected to a compressor through a bearing casing, the bearing casing defining an annular cooling fluid passage and the turbine including a housing which defines a space accommodating a turbine wheel and an inlet passage which communicates with the said space via an annular passage, a plurality of circumferentially spaced nozzle blades being positioned in the said annular passage for guiding exhaust gases to the turbine wheel, the nozzle blades being connected to one end of respective rotatable nozzle shafts which are also connected to a common nozzle blade drive mechanism which is operable to adjust the angle of all the nozzle blades in unison, is characterised in that the nozzle shafts are rotatably supported by the bearing casing at posi-

tions adjacent the cooling fluid passage.

Thus in the turbocharger in accordance with the present invention the nozzle shafts are supported for rotation, preferably in respective bearings, not in the turbine housing but in the bearing casing at positions adjacent the annular cooling fluid passage. The nozzle shafts are thus retained at a relatively low temperature due to their proximity to the cooling fluid passage and may thus be satisfactorily lubricated without the lubricant being carbonised.

The nozzle blade drive mechanism may be received in a space defined by the turbine and the bearing casing or in a space defined by the compressor and the bearing casing. It is preferred that there are means, e.g. one or more passages, for supplying lubricating oil to the space which receives the nozzle blade drive mechanism.

In accordance with a further aspect of the present invention, which may be used alone or in combination with the first aspect referred to above, a turbocharger of the type including a turbine including a housing which defines a space accommodating a turbine wheel and an inlet passage which communicates with the said space via an annular passage, a plurality of circumferentially spaced nozzle blades being positioned in the said annular passage for guiding exhaust gases to the turbine wheel, the nozzle blades being connected to one end of respective rotatable nozzle shafts which are also connected to a common nozzle blade drive mechanism which is operable to adjust the angle of all the nozzle blades in unison, is characterised in that the nozzle blade drive mechanism includes a plurality of links, each of which is rigidly secured to a respective nozzle shaft, each adjacent pair of links, with the exception of one such pair, being connected by a respective connector which is pivotally connected to both links, one nozzle shaft being connected to a drive lever to be rotated thereby.

Thus in this aspect of the invention the connectors, which may constitute elongate plates or bars, are connected to adjacent links at points on the links such that the distance between these points on adjacent links is equal to the distance between adjacent nozzle shafts. The points on the links will be spaced from the associated nozzle shaft by a predetermined distance. A drive lever is connected to one of the nozzle shafts and as this is rotated not only does the associated nozzle shaft rotate but also the associated link whereby, due to the presence of the connector, the adjacent link and thus the adjacent nozzle shaft also rotate in the same sense. The rotation is transmitted from link to link whereby all the links and nozzle shafts rotate simultaneously by the same amount in the same sense. The drive lever may be connected to the associated nozzle shaft either directly or indirectly via the link. The links may constitute plates with three spaced connection points or any suitably shaped member. Due to the fact that there is one pair of adjacent links which are not connected, the nozzle blade drive mechanism has the ability to absorb dimensional tolerances and thermal expansion.

Further features and details of the present invention will be apparent from the following description of certain preferred embodiments which is given by way of example with reference to Figures 3 to 7 of the accompanying diagrammatic drawings, in which:

Figure 3 is a longitudinal sectional view of a first preferred embodiment of the present invention;

Figure 4 is a sectional view on the line IV-IV in Figure 3;

Figure 5 is a longitudinal sectional view of a second preferred embodiment of the present invention;

Figure 6 is a transverse sectional view of a third preferred embodiment of the present invention; and

Figure 7 is a transverse sectional view of a fourth preferred embodiment of the present invention.

The same reference numerals are used to designate similar parts throughout the Figures.

Referring firstly to Figure 3, outwardly extending, axially spaced large and small flanges 31 and 32 are formed around the outer periphery of the bearing casing 3 in the vicinity of the cooling water passage 27. The flange 31 defines with the casing 4 a toroidal space 33 surrounding that portion of the bearing casing 3 which, by virtue of the cooling water passage 27, constitutes a water jacket. The flange 32 radially engages a portion of the casing 4 and has an annular heat shield plate 34 which is securely attached to the surface of the flange 32 adjacent to the turbine wheel 24. The shield plate 34 and the flange 32 rotatably support the nozzle shafts 35 which extend in the axial direction of the turbine shaft 26 through respective bearings 36. The nozzle shafts 35 have respective nozzle blades 9 securely attached to that end which is adjacent to the turbine wheel 24. The other end of the nozzle shafts 35 adjacent to the space 33 is connected to a nozzle blade drive mechanism 37.

The nozzle blade drive mechanism 37 is shown in Figure 4 and comprises a link plate 38, associated with each shaft 35, in the form of, for example, an equilateral triangle or a letter T or Y with vertexes 38a, 38b and 38c, the distance between the vertexes 38a and 38b and between the vertexes 38a and 38c being a. The first or top vertex 38a of each link plate 38 is securely attached to the other end of the associated shaft 35. The third

vertex 38c of each link plate 38 is pivotally connected to the second vertex 38b of the adjacent link plate 38 by a connecting plate or bar 39 whose length is equal to the distance b between the top vertexes 38a of the link plates 38 or between the adjacent nozzle shafts 35. The link plates 38 are sequentially interconnected in this manner with a single discontinuity 41 whereby only two adjacent link plates are not so connected. Thus a plurality of parallelogram linkages with vertexes 38a, 38a, 38c and 38b are provided. Thus when one link plate 38 is rotated through an angle, the angle of the nozzle blade 9 attached to the corresponding shaft 35 is varied by the same amount and this motion is transmitted through the connecting plates 39 to all the link plates 38 in sequence, whereby the angles of all the nozzle blades 9 are varied simultaneously.

The second vertex 38b of one link plate 38′ adjacent the discontinuity, which is securely attached to for instance the nozzle blade 9′ which is the most upstream in the flow of the exhaust gases from the turbine inlet 40 into the volute passage, is not connected to the third vertex 38c of the other link plate 38″ adjacent the discontinuity which is attached to the most downstream nozzle blade 9″, thereby defining the unconnected section or discontinuity 41 which absorbs any adverse effects due to dimensional tolerances and thermal expansion of the plates 38 and 39.

A drive lever 42, which extends through and beyond the wall of the turbine casing 4, is securely attached to the link plate 38′. An actuator 43, such as an air cylinder, is connected to the outer end of the lever 42 to move the latter to cause swinging motion of the link plates 38′, 38 and 38″.

Alternatively, as indicated by the chain dotted line in Figure 3, a drive lever 42′ may be securely attached to an extension 44 of one of the nozzle shafts 35.

The mode of operation of the embodiment described above is as follows: When the drive lever 42 is rotated by actuation of the actuator 43, the link plate 38′ rigidly attached to the lever 42 is swung to vary the angle of the nozzle blade 9′.

Simultaneously, the swinging motion of the link plate 38′ is transmitted through the connecting plates 39 to the link plates 38 and 38″ so that they are swung also and vary the angles of the nozzle blades 9 and 9″.

Each adjacent pair of link plates 38 and the associated connecting plate 39 provides a parallelogram linkage so that when the link plates 38 are swung, the connecting plate 39 can displace in the radial direction of the turbine wheel 24. There is no need to design the connecting plate 39 to be slidable in the radial direction with respect to the link plate 38. The swinging motion is caused only by the use of pin joints at the connections of the connecting plates with the link plates so that no slide elements liable to oxidation at high temperatures and wear are provided. Thus the service life and reliability of the device are remarkably improved.

As described above, the upstream link plate 38′ and the downstream link plate 38″ are unconnected to define a discontinuity 41 for absorbing variations in size and thermal expansion of the plates 38, 38″ and 39. It is thus possible to decrease the distance b between the adjacent nozzle shafts 35 so as to increase the number of the connecting plates 39, the link plates 38 and the nozzle blades 9 and so as to ensure smooth operation thereof.

Because of the presence of the unconnected section 41, the drive force transmitted from the lever 42 to the link plates 38 become weaker as the distance of the link plates 38 from the lever 42 is increased. However, since the lever 42 is securely attached to the most upstream link plate 38′, the nozzle blade 9′, which is most affected by the pulsations in the exhaust gases is acted on by the greatest force to accomplish reliable angular adjustment.

The nozzle shafts 35, which are supported by the water jacket of the bearing casing 3, are cooled by the water circulating through the passage 27. Heat from the nozzle blades 9 is thus prevented from being transmitted through the nozzle shafts 35 to the nozzle blade drive mechanism 37 so that a substantial rise in temperature of the drive mechanism 37 is avoided.

Breakdown of the nozzle shafts 35 and the drive mechanism 37 due to oxidisation at high temperatures and wear can be suppressed thereby improving the service life and reliability of the drive mechanism and thus of the turbocharger.

The second embodiment of the invention shown in Figure 5 is substantially similar to the first embodiment except that the nozzle shafts 35′ extend to the compressor 2 over the full length of the bearing casing 3 and the nozzle blade drive mechanism 37, to which they are connected, is disposed within a toroidal space 33′ defined between the bearing casing 3 and the compressor 2.

The effects and advantages of the second embodiment are the same as those of the first embodiment. The nozzle shafts 35′ and the bearings 36 are cooled by the water circulating through the water passage 27 so that the nozzle shafts 35′ are less subject to thermal expansion. Furthermore, the nozzle blade drive mechanism 37 is cooled by the air compressed by the compressor 2 to a lower temperature (about 150°C) as compared with the first embodiment. As a result, oxidisation at high temperatures in excess of about 300°C can be

substantially completely eliminated. Lubrication is effected by providing a supply passage 45 or 45′ for the lubricating oil (which may be carbonised at about 200 °C) in communication with the oil supply opening 28 or the oil discharge opening 29 so that the problem of wear is solved and the service life and reliability are considerably improved as compared with the first embodiment. (The supply passage 45 provides forced lubrication and the supply passage 45′ provides mist lubrication).

The third embodiment shown in Figure 6 is again substantially similar to the first and second embodiments except that the inner end of the drive lever 42″ is directly rigidly attached to the nozzle shaft 35 of the link plate 38′.

The fourth embodiment shown in Figure 7 is again substantially similar to the first and second embodiments. The difference resides in that the inner end of the drive lever 42‴ is connected by a pivot pin 46 to the turbine casing (not shown) and is pivotally connected through a connecting pin or rod 47 to the link plate 38′. The effects and advantages of the third and fourth embodiments are substantially similar to those attained by the first and second embodiments.

It will be understood that various modifications may be effected without departing from the scope of the present invention. For instance, the links and connecting plates may have any suitable shapes, the drive lever may be coupled to the links in any convenient manner and the unconnected section 41 may be at any suitable position.

Claims

1. A turbocharger including a turbine (1) connected to a compressor (2) through a bearing casing (3), the bearing casing (3) defining an annular cooling fluid passage (27) and the turbine including a housing (4) which defines a space accommodating a turbine wheel (24) and an inlet passage which communicates with the said space via an annular passage, a plurality of circumferentially spaced nozzle blades (9) being positioned in the said annular passage for guiding exhaust gases to the turbine wheel (24), the nozzle blades (9) being connected to one end of respective rotatable nozzle shafts (35) which are also connected to a common nozzle blade drive mechanism (37) which is operable to adjust the angle of all the nozzle blades (9) in unison, characterised in that the nozzle shafts (35) are rotatably supported by the bearing casing (3) at positions adjacent the cooling fluid passage (27).

2. A turbocharger as claimed in claim 1 characterised in that the nozzle blade drive mechanism (37) is received in a space defined by the turbine (1) and the bearing casing (3).

3. A turbocharger as claimed in claim 1 characterised in that the nozzle blade drive mechanism (37) is received in a space defined by the compressor (2) and the bearing casing (3).

4. A turbocharger as claimed in claim 3 characterised by means (45 or 45′) for supplying lubricating oil to the space receiving the nozzle blade drive mechanism.

5. A turbocharger including a turbine (1) including a housing (4) which defines a space accommodating a turbine wheel (24) and an inlet passage which communicates with the said space via an annular passage, a plurality of circumferentially spaced nozzle blades (9) being positioned in the said annular passage for guiding exhaust gases to the turbine wheel (24), the nozzle blades (9) being connected to one end of respective rotatable nozzle shafts (35) which are also connected to a common nozzle blade drive mechanism (37) which is operable to adjust the angle of all the nozzle blades (9) in unison, characterised in that the nozzle blade drive mechanism includes a plurality of links (38′,38, 38″) each of which is rigidly secured to a respective nozzle shaft (35), each adjacent pair of links (38), with the exception of one such pair (38′,38″), being connected by a respective connector (39) which is pivotally connected to both links (38), one nozzle shaft (35) being connected to a drive lever (42) to be rotated thereby.

6. A turbocharger as claimed in claim 5 characterised in that the drive lever (42) is connected to the nozzle shaft (35) of that nozzle blade (9) which is situated the most upstream with respect to the flow of air through the turbine.

7. A turbocharger as claimed in claim 5 or claim 6 characterised in that the nozzle shafts (35) are rotatably supported by the bearing casing (3) at positions adjacent the cooling fluid passage (27).

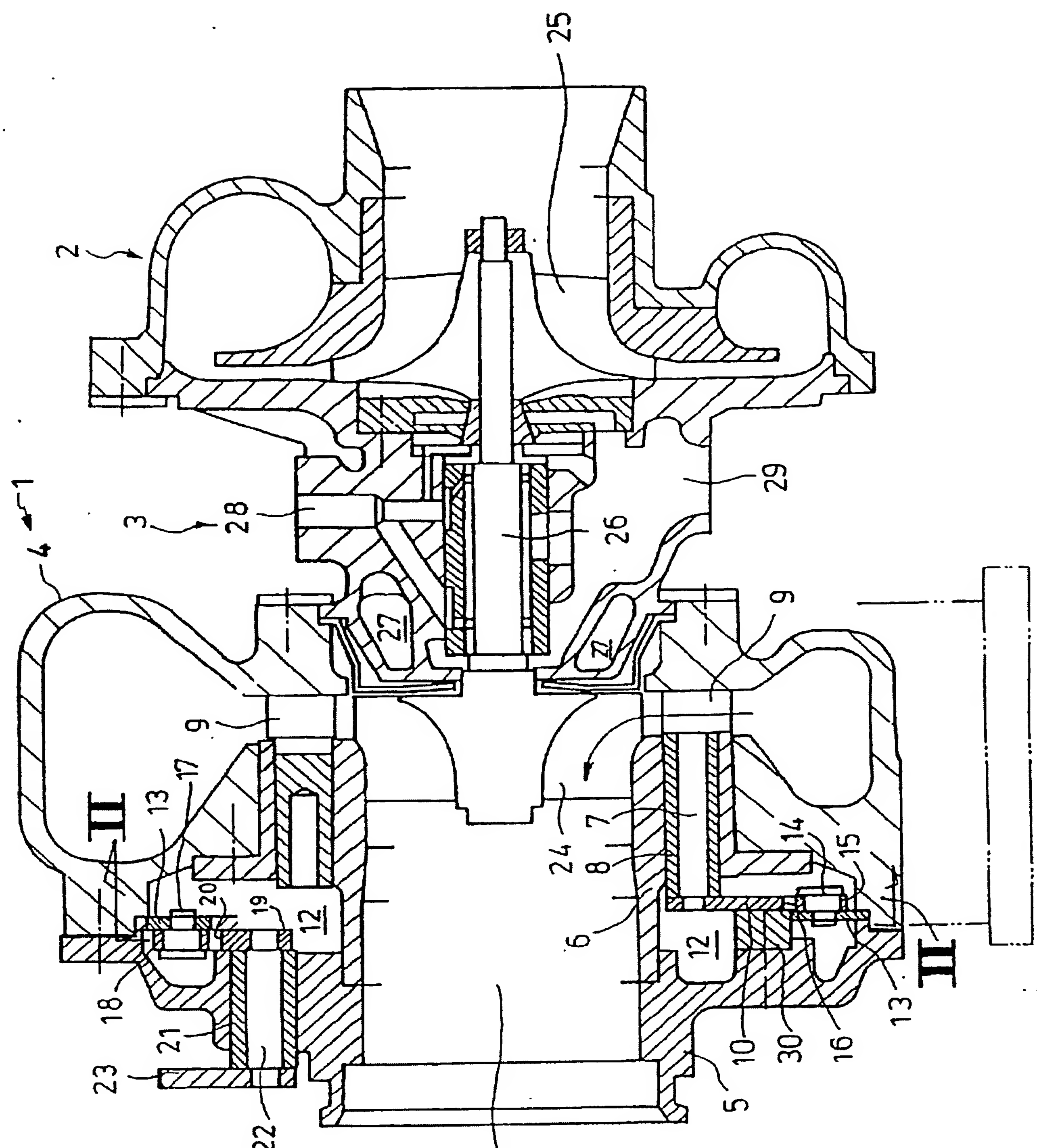

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Fig.1

Fig. 2

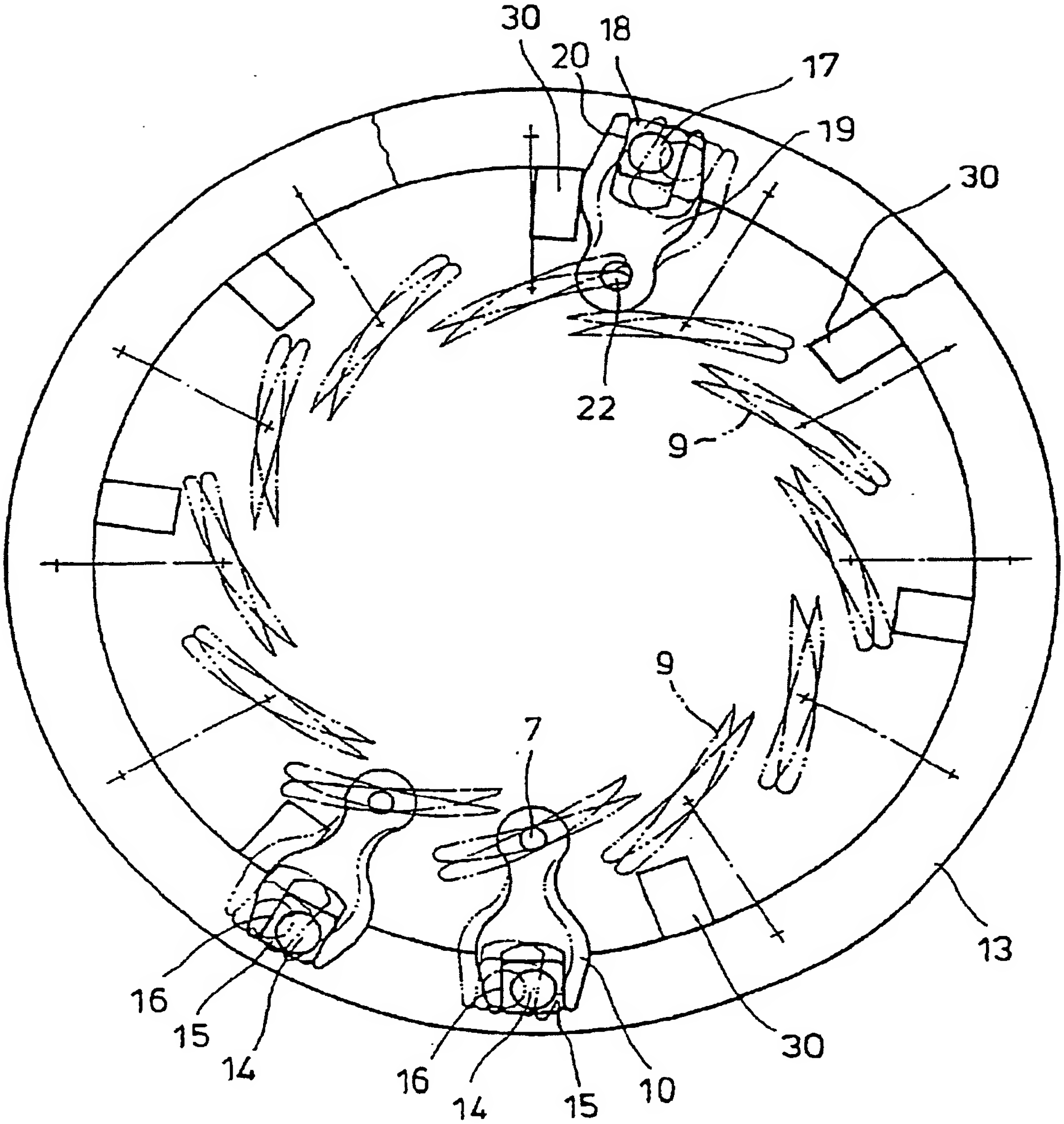

Fig. 3

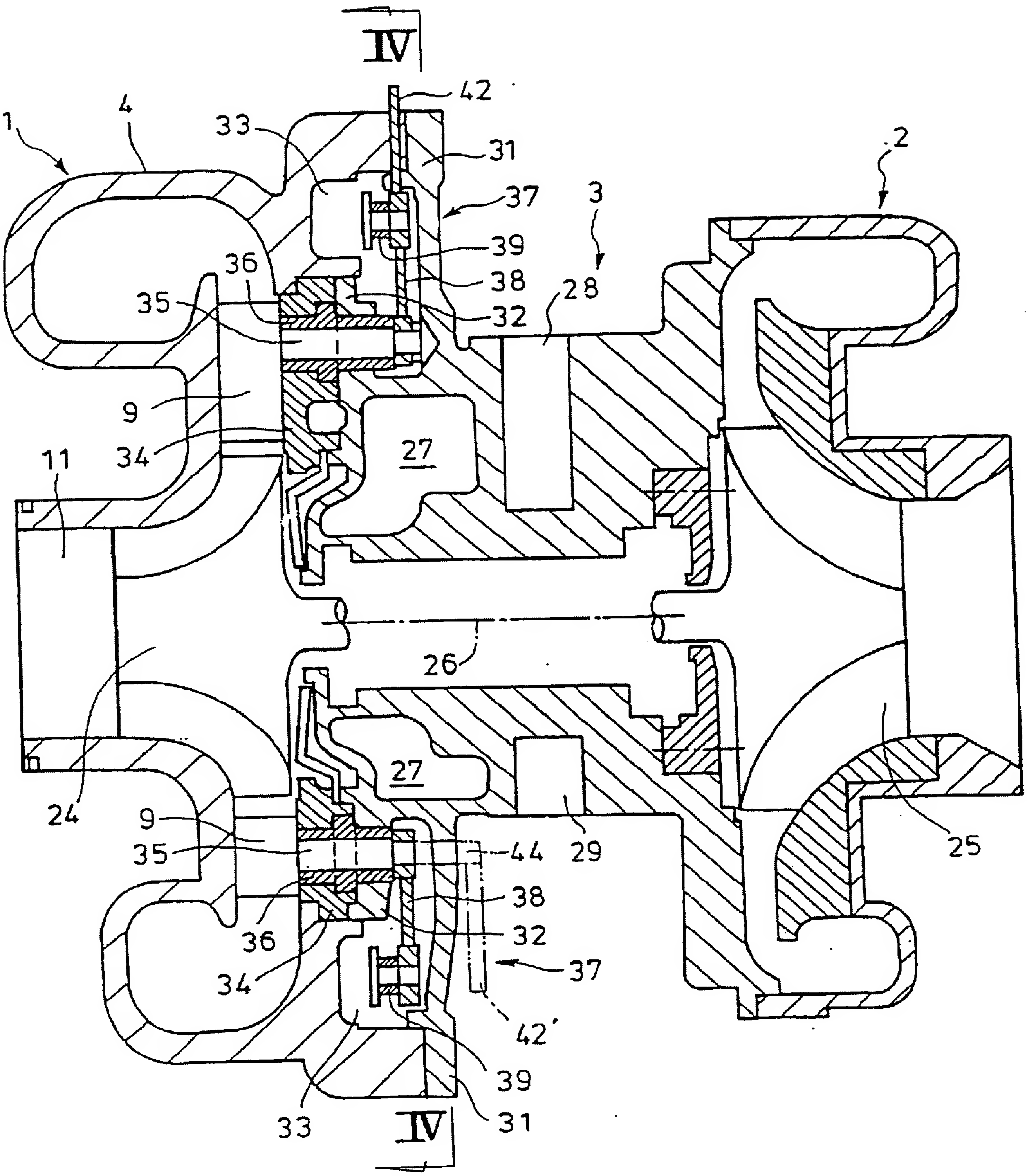
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Fig. 4

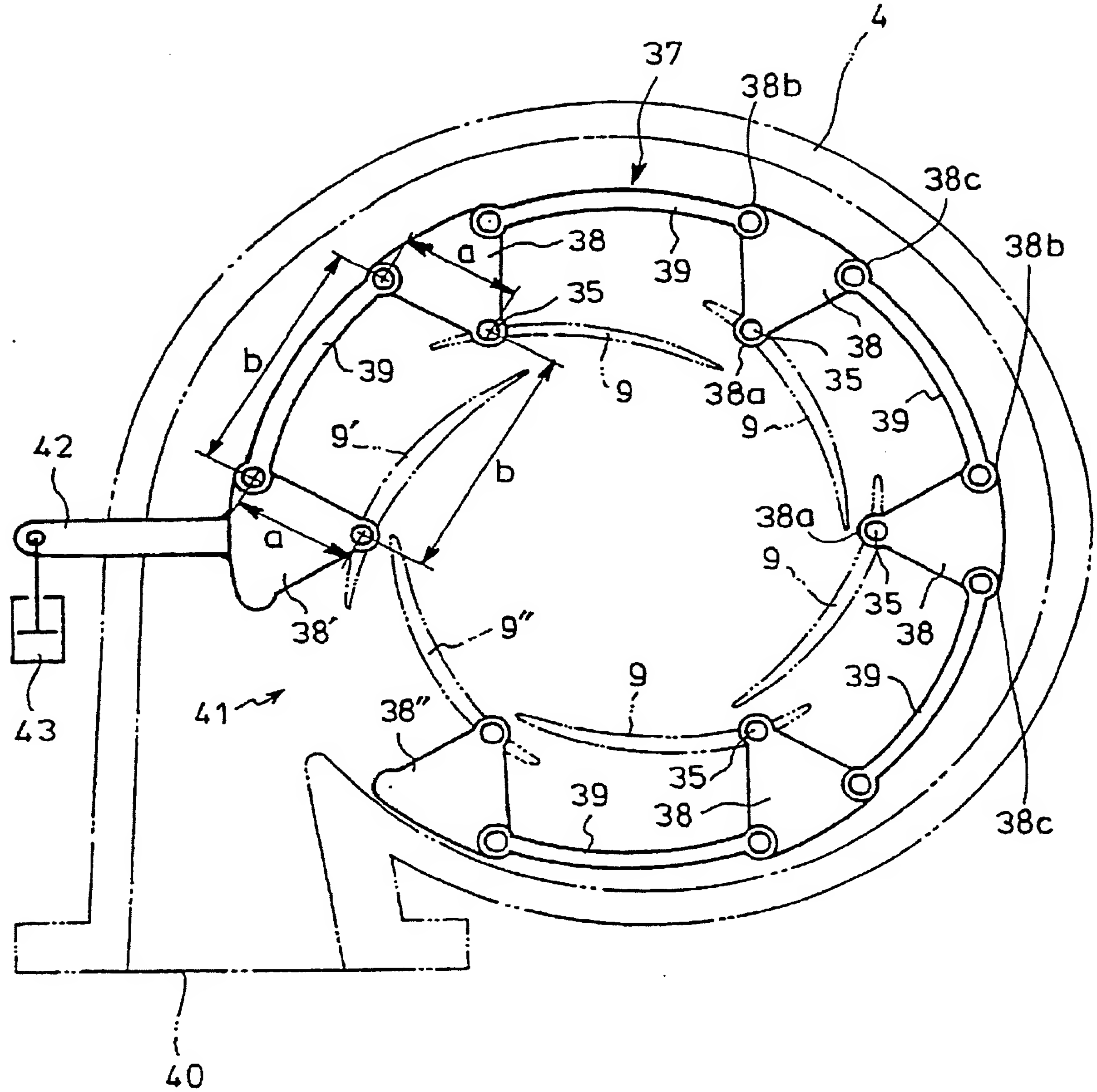
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Fig. 5

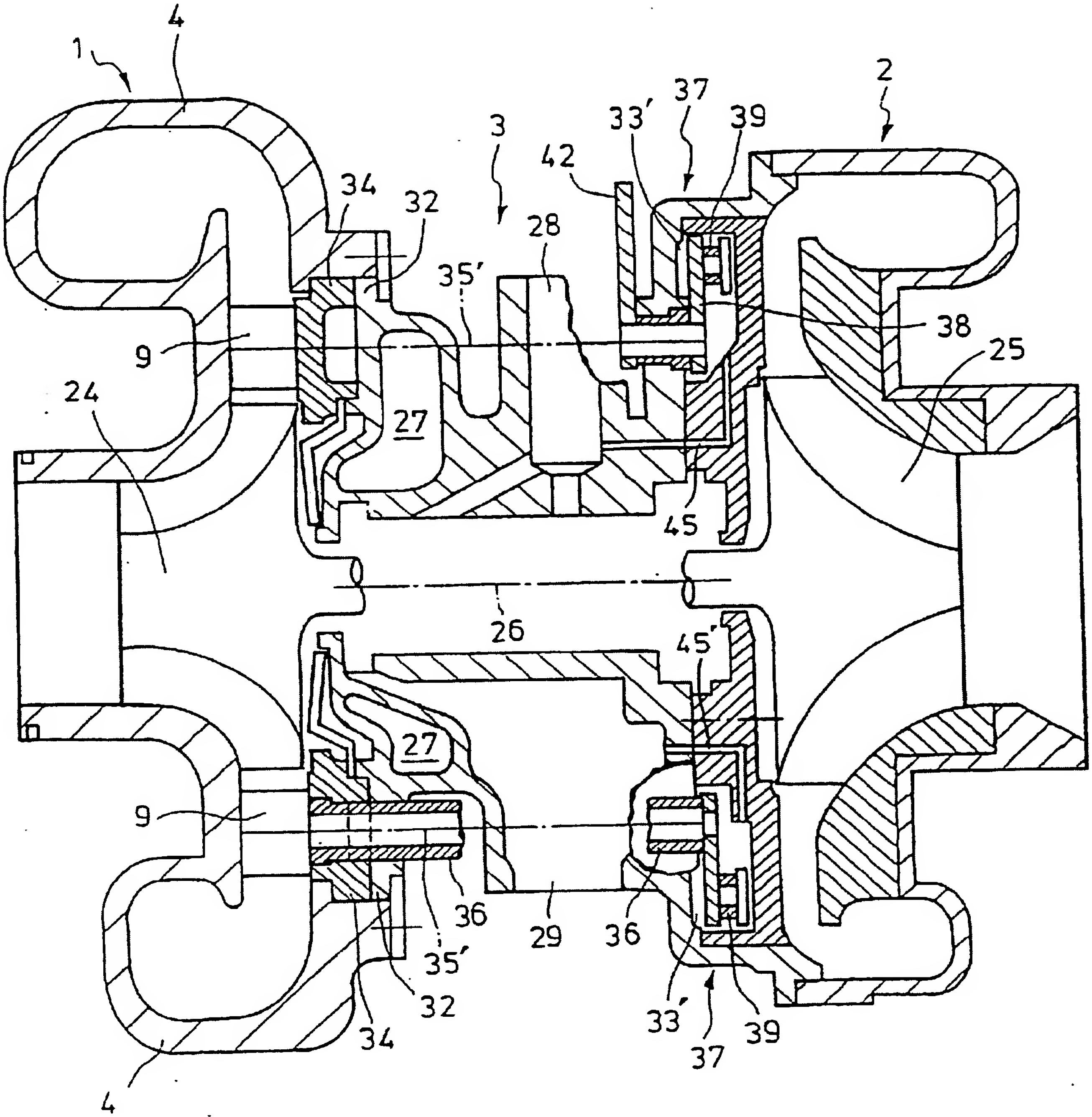
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Fig. 6

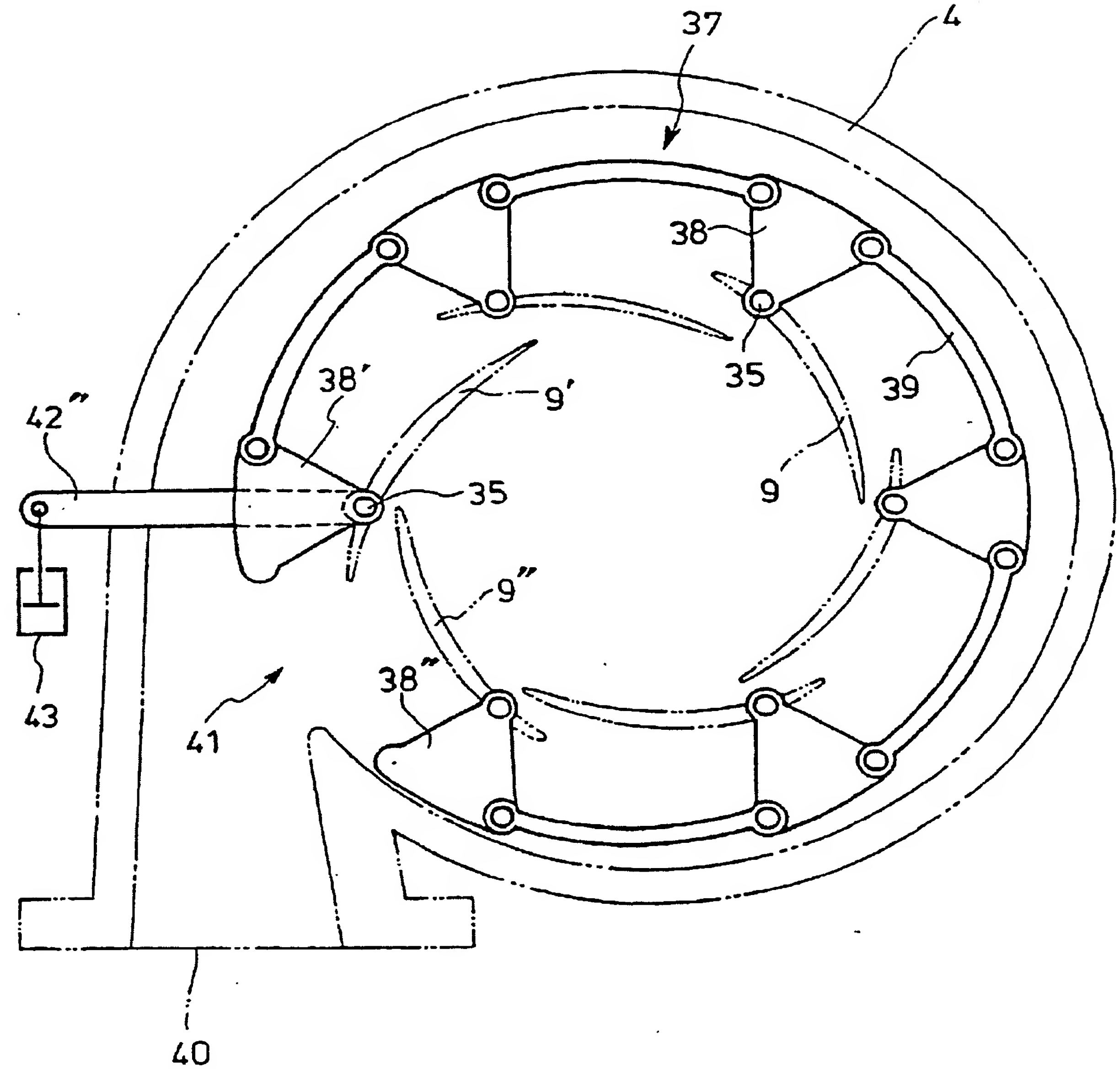
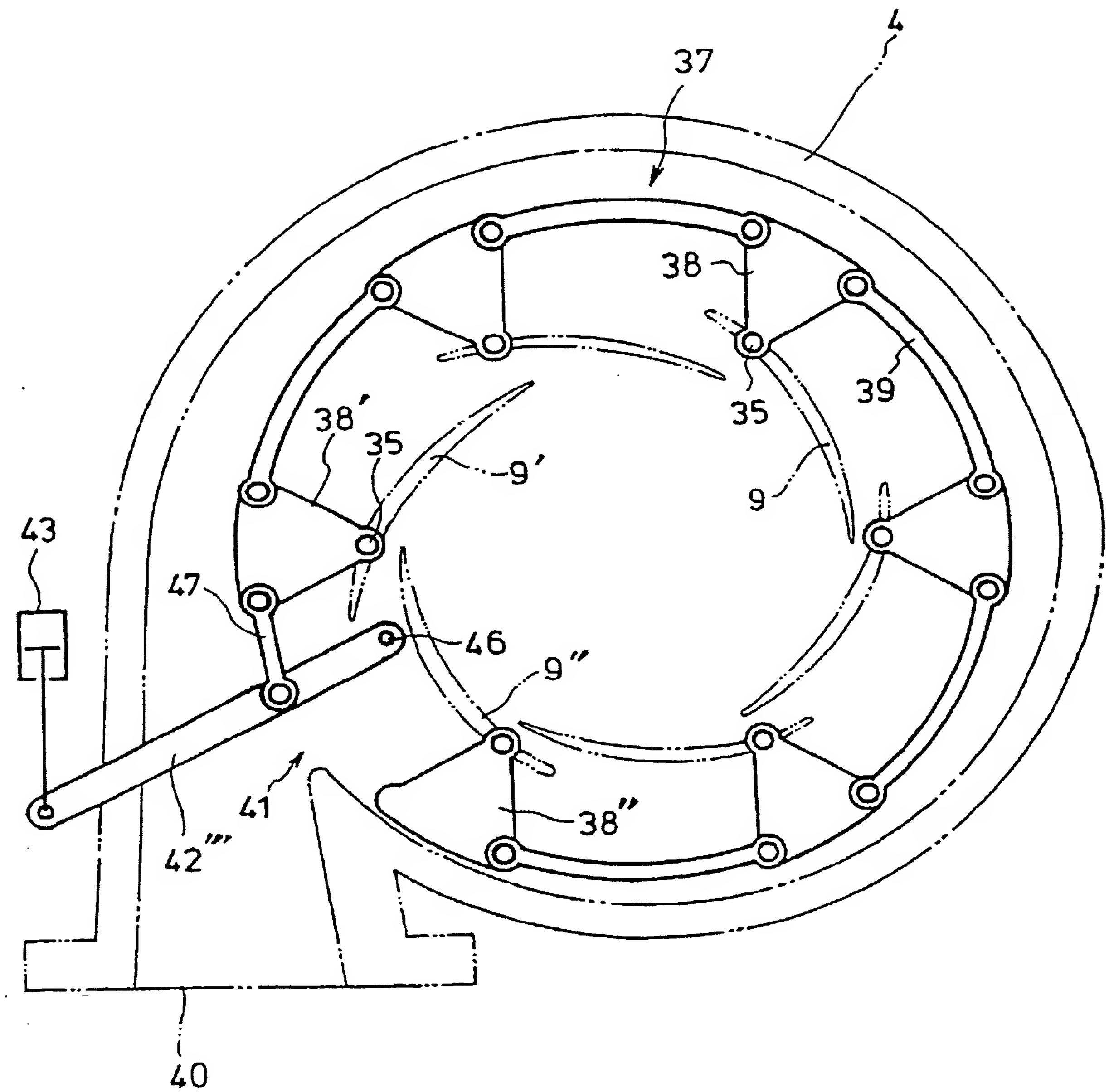


Fig.7



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EUROPEAN SEARCH REPORT

Application Number

EP 90 30 0196

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	EP-A-270384 (INOUE) * page 3, line 14 - page 5, line 48; figures 1-4 *	1, 2	F01D17/16 F01D25/12 F02C6/12
X	EP-A-224083 (ENGELS) * page 2, line 30 - page 9, line 8; claim 6; figures 1, 2 *	1, 2	
X	DE-B-1247753 (FELDINGER) * the whole document *	1, 2, 4	
X	EP-A-276023 (YANO) * the whole document *	1, 2	
X	US-A-3682570 (KAPLANSKY) * the whole document *	5	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 47 (M-456)(2104) 25 February 1986, & JP-A-60 198306 (YOUICHIROU OKAZAKI) 07 October 1985, * the whole document *	5	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-3069070 (MACALUSO) * column 2, line 60 - column 2, line 72; figure 3 *	5	F01D
P,X	EP-A-299280 (HOTZ) * the whole document *espcially col.6, lines 41 to 56	5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	05 APRIL 1990	IVERUS D.

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CATEGORY OF CITED DOCUMENTS

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